



The AFTA-WFIRST Coronagraph and Mission Impact

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New Worlds, New Horizons



The most profound discovery in the coming decade may be the detection of potentially habitable Earth-like planets orbiting other stars. To find evidence that life exists beyond our Earth is a longstanding dream of humanity, and it is now coming within our reach. . . . Thus, the plan for the coming decade is to perform the necessary target reconnaissance surveys to inform next-generation mission designs while simultaneously completing the technology development to bring the goals within reach. This decade of dedicated preparatory work is needed so that, one day, parents and children can gaze at the sky and know that a place somewhat like home exists around "THAT" star, where life might be gaining a toehold somewhere along the long and precarious evolutionary process that led, on Earth, to humankind. And perhaps it is staring back at us!



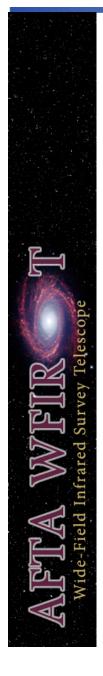
New Worlds, New Horizons

New Worlds Technology Development Program – #1 Medium Priority

To prepare for this endeavor, the committee recommends a program to lay the technical and scientific foundations for a future space imaging and spectroscopy mission. . . . In the first part of the decade NASA should support competed technology development to advance multiple possible technologies for a next-decade planet imager, and should accelerate measurements of exozodiacal light levels that will determine the size and complexity of such missions. . . .

Together with the TDEM program for other technologies, the coronagraph on AFTA advances key technologies to TRL 9 through a competitive process while simultaneously accomplishing profound scientific goals.





The culmination of the quest for nearby, habitable planets is a dedicated space mission. The committee concluded that it is too early to determine what the design of that space mission should be, or even which planet-detection techniques should be employed.10 It is not even clear whether searches are best carried out at infrared, optical, or even ultraviolet wavelengths. This choice awaits the results of the observational studies just described, alongside a vigorous and adaptive program of theoretical and laboratory astrophysics investigations that will inform scientists about the diversity of exoplanet atmospheres. Although the case is compelling for technology development for a future space mission beginning early, its emphasis may shift as new discoveries from the ground and space materialize. If progress is sufficiently rapid by mid-decade, then a decadal survey implementation advisory committee (as discussed in Chapter 3) could determine whether a more aggressive program of technology development should be undertaken, possibly including steps toward a technology down-select and a focus on key elements. Either way, decisions on significant, mission-specific funding of a major space mission should be deferred until the 2020 decadal survey, by which time the scientific path forward should be well determined.



Recommendations for New Space Activities—Medium Projects

Priority 1 (Medium, Space). New Worlds Technology Development Program for a 2020 Decade Mission to Image Habitable Rocky Planets

. . . characterize the level of zodiacal light
Present so as to determine, in a statistical sense if not for
individual prime targets, at what level starlight scattered from
dust will hamper planet detection. . . . A range of measurement
techniques must be strongly supported to
ensure that the detections extend to the relevant Earth-Sun
distance range for a sufficient sample of
systems.

candidate starlight suppression techniques (for example, interferometry, coronagraphy, or star shades) should be developed to a level such that mission definition for a space-based planet imaging and spectroscopy mission could start late in the decade . . . If the scientific groundwork has been laid and the design requirements for an imaging mission have become clear by the second half of this decade, a technology down-select should be made.



EOS Panel Report, NWNH

Exoplanet Mission

Direct detection and spectroscopy are compelling for both their scientific and their "exploration" value. Even low resolution spectra can distinguish between planetary atmospheres dominated by water or by methane, and can identify non-equilibrium abundances that could indicate the presence of life on other worlds. . . .

The panel urges increased technology development for these techniques and recommends that one of these missions, or a yet-to-be-developed approach, be competitively selected around mid-decade and, if the budget permits, started before the end of the decade.

Coronagraph for AFTA will address compelling scientific questions and advance technology to TRL 9. Specific technology selected through TDEMs and competitive process.



EOS Panel Report, NWNH



The panel did evaluate, and found appealing, several "probeclass" concepts employing ~1.5-m primary mirrors and internal starlight suppression systems, often coronagraphs with advanced wavefront control. . . . Such a mission could image about a dozen known (radial velocity) giant planets and search hundreds of other nearby stars for giant planets. Importantly, it could also measure the distribution and amount of exozodiacal disk emission to levels below that in our own solar system (1 zodi) and detect super-Earth planets in the habitable zones of up to two dozen nearby stars. These would be extremely important steps, both technically and scientifically, toward a mission that could find and characterize an Earth-twin.

Coronagraph for AFTA accomplishes, or exceeds, these scientific goals at much lower cost than a probe and with minimal impact on WFIRST.



AFTA Coronagraph



AFTA Coronagraph Responds to NWNH goals by:

- Characterizing the spectra of over a dozen radial velocity planets.
- Discovering and characterizing up to a dozen more ice and gas giants.
- Providing crucial information on the physics of planetary atmospheres and clues to planet formation.
- Measuring the exozodiacal disk level about nearby stars.
- Disks?
- Maturing critical coronagraph technologies (common to many types), informing a future technology downselect for an Earth-like planet imaging mission.

With minimal impact on WFIRST spacecraft.



Next Slides

Philosophy for coronagraph inclusion: no additional requirements imposed on observatory that could increase cost or risk.

Slide selection on coronagraph design and technology downselect (emphasize the advancement of multiple coronagraph technologies- DMs, LOWFS, Masks, Multiple coronagraphs, data processing)

Summary of science goals and preliminary predictions (including Zodi measurements?)

Impact on observatory, directly addressing the committee's questions.



NRC Question

Provide a summary of how mission parameters are affected by the inclusion of coronagraphy. Specifically, these parameters are as follows:

- Pointing accuracy and pointing stability
- Detector+readout performance including sensitivity, stability, and dynamic range
- Payload mass
- Straylight and baffling
- Optical quality (eg. PSF)







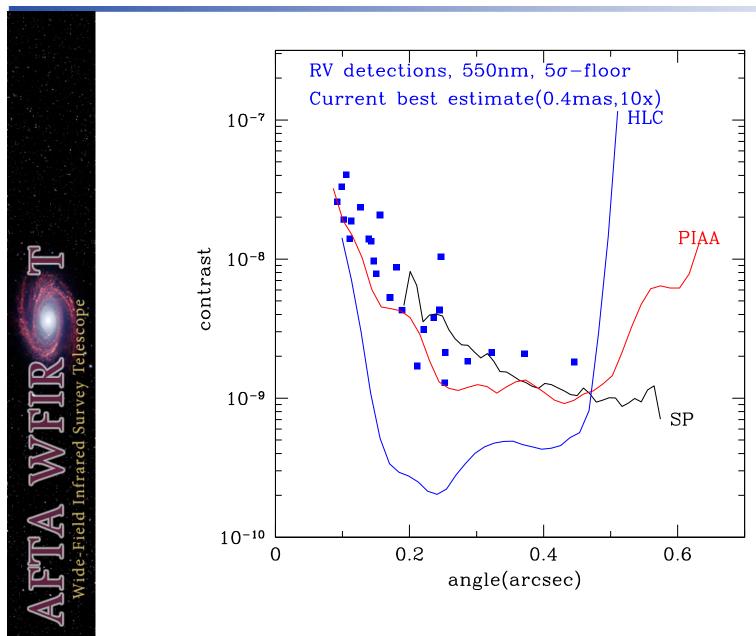
Outline



- Introduction
- AFTA overview & microlensing
- Science goals
- Coronagraph architecture
- Initial evaluation of exoplanet coronagraph capabilities
- Status and next steps



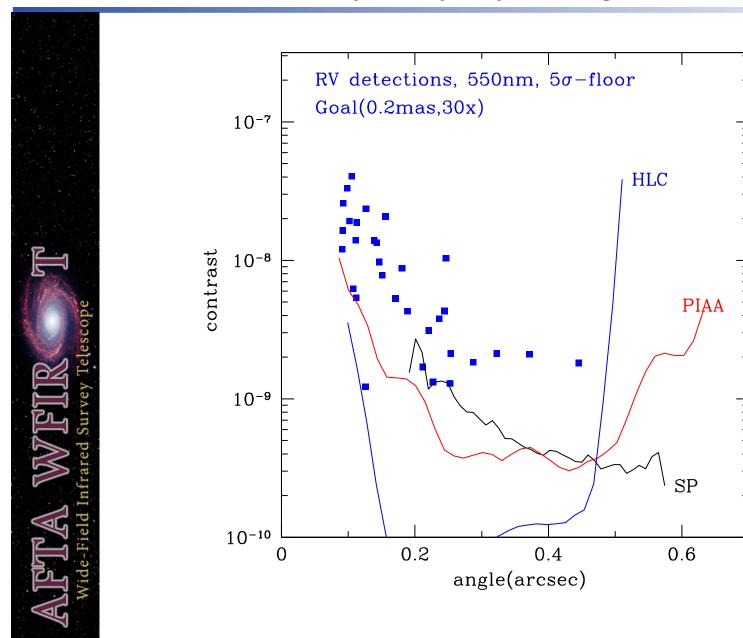
Contrast vs Angle from Star Current best estimate jitter & post-processing factor



Contrast floors here are upper limit for long exposure/very bright star



Contrast vs Angle from Star Goal jitter & post-processing factor



Contrast floors here are upper limit for long exposure/very bright star



AFTA RV Exoplanet Detection Estimates

 RV exoplanet detections are estimated based on imaging of radial velocity planets from the current RV catalog

Configuration	Design	Inner working angle	# RV planets, 550nm band, 6-month campaign	# spectral bands per target, 6-month campaign
Prime (OMC: Occulting Mask Coron.)	SP	0.19	4	4.3
			7	4.9
	HL	0.10	18	4.3
			19	4.2
Backup	PIAA	0.09	23	3.2
			30	4.3

Note 1. Two rows for contrast and # RV images columns are for cases of

- Current Best Estimate: 0.4 mas RMS jitter & 1 mas star, 10x post-processing factor (slide 4)

- Goal: 0.2 mas RMS jitter & 1 mas star, 30x post-processing factor (slide 5)

Note 2. Spectral bands are 10% wide, centered at 450, 550, 650, 800, 950 nm